DAIRYING

at the

Ohio Agricultural Experiment Station

AUGUST 1930 to AUGUST 1933

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Dairying

at the

OHIO AGRICULTURAL EXPERIMENT STATION

No. III

Wooster, Ohio

This circular contains summaries of some of the projects completed or under way since Circular No. 29 was published in August, 1930

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OHIO AGRICULTURAL EXPERIMENT STATION

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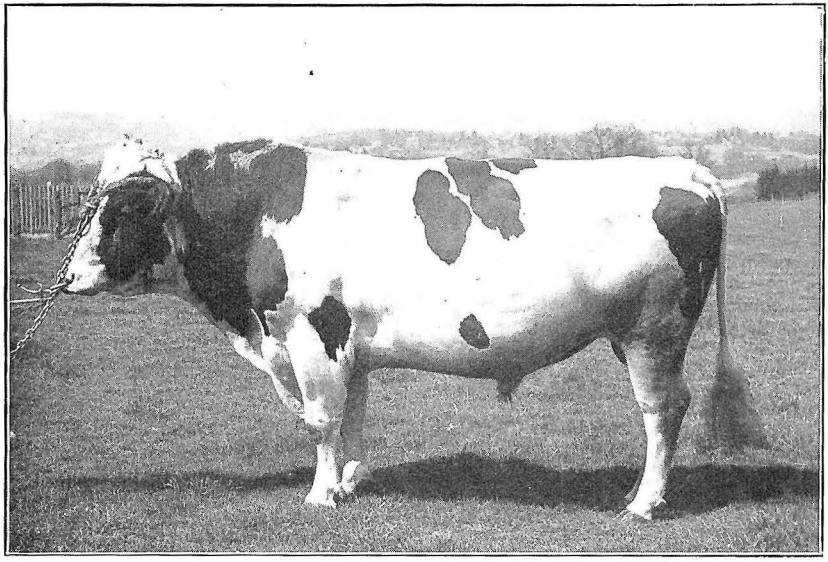

Tina Clay De Kol Lad 42450

The first Holstein-Friesian sire used in the Station herd, complete records of whose daughters are available

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BREEDING

THREE GOOD JERSEY SIRES

The Station has been lucky in securing three successive Jersey bulls, selected as calves, which have been reasonably satisfactory as sires.

Every heifer from these sires which has lived to complete one year of production has produced more than enough to meet Register of Merit requirements when milked only twice daily. Every heifer which has been sired in the herd in the last 8 years and which has completed one year of production has met the above requirements.

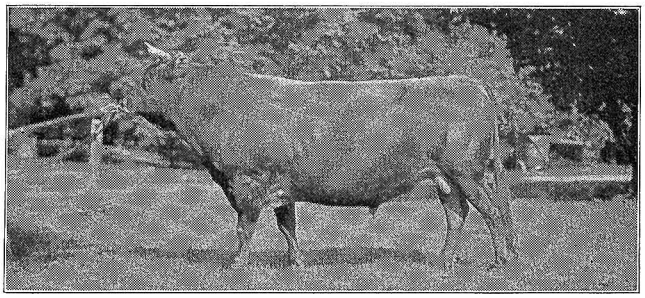

Fig. 1.—Choice Owl 175407

Choice Owl's daughters produced much more than their mothers, and they were, on the whole, better in type. He is now listed by the American Jersey Cattle Club among the "Tested Sires", with a rating of 10,600 pounds of milk and 583 pounds of butterfat. No daughters were culled out on the basis of low production. This represents the average of the records of his daughters calculated to mature equivalents.

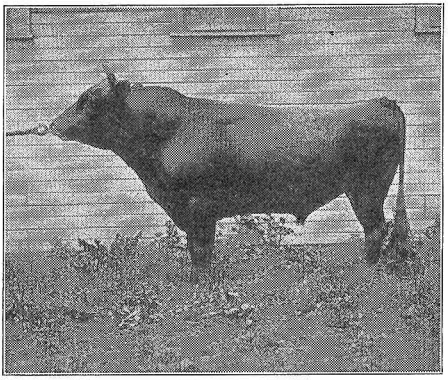

Fig. 2.—Dean Hill Owl 255587

The second sire, Dean Hill Owl, did not quite maintain Choice Owl's standard of fat production but improved greatly the type, especially udder type.

"Dean" also is in the list of "Tested Sires" with a rating of 9,877 pounds of milk and 510 pounds of fat. This rating was based on 2-year-old records, and some of his daughters are not yet old enough to be tested. None has been culled out because of low production. He was an inbred bull.

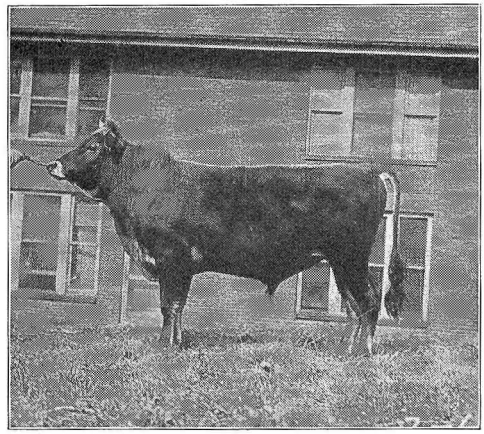

Fig. 3.—Maplewood's Owl 312137

Only three of Maplewood's Owl's daughters are in milk to date. They promise to equal the daughters of the two preceding bulls in production. Unfortunately, this bull died before siring many daughters.

The Station now has the best herd of Jerseys it has ever had.

A GESTATION TABLE FOR COWS

Carefully kept breeding records of the Station herd for a period of 30 years show that about 50 per cent of the cows dropped their calves between the 275th and the 285th days after service and 90 per cent between the 270th and the 290th days. This agrees quite closely with other published data and shows that, although the average length of time is about 280 days, there is a considerable variation. About 20 per cent will calve between the 270th and the 275th days, 25 per cent between the 275th and the 280th days, 25 per cent between the 280th and 285th days, and 20 per cent between the 285th and 290th days.

Gestation tables published are based on the average of about 280 days. This is only an average, and every cow should be considered due 10 days earlier and treated accordingly. In 90 per cent of the cases she will calve any time from 10 days before to 10 days after the 280th day. None of the calves dropped within this time should necessarily be considered premature or over-due.

TABLE 1.—Gestation Table

(Consider your cow due 10 days earlier than indicated in this table)

Served	Due	Served	Due	Served	Due	Served	Due	Served	Due	Served	Due	Served	Due	Served	Due	Served	Due	Served	Due	Served	Due	Served	Due
Jan.	*Oct.*	*Feb.*	*Nov.*	*Mar.*	*Dec.*	*Apr.*	*Jan.*	*May*	*Feb.*	*June*	*Mar.*	*July*	*Apr.*	*Aug.*	*May*	*Sept.*	*June*	*Oct.*	*July*	*Nov.*	*Aug.*	*Dec.*	*Sept.*
1	8	1	8	1	6	1	6	1	5	1	8	1	7	1	8	1	8	1	8	1	8	1	7
2	9	2	9	2	7	2	7	2	6	2	9	2	8	2	9	2	9	2	9	2	9	2	8
3	10	3	10	3	8	3	8	3	7	3	10	3	9	3	10	3	10	3	10	3	10	3	9
4	11	4	11	4	9	4	9	4	8	4	11	4	10	4	11	4	11	4	11	4	11	4	10
5	12	5	12	5	10	5	10	5	9	5	12	5	11	5	12	5	12	5	12	5	12	5	11
6	13	6	13	6	11	6	11	6	10	6	13	6	12	6	13	6	13	6	13	6	13	6	12
7	14	7	14	7	12	7	12	7	11	7	14	7	13	7	14	7	14	7	14	7	14	7	13
8	15	8	15	8	13	8	13	8	12	8	15	8	14	8	15	8	15	8	15	8	15	8	14
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22	29	22	29	22	27	22	27	22	26	22	29	22	28	22	29	22	29	22	29	22	29	22	28
23	30	23	30	23	28	23	28	23	27	23	30	23	29	23	30	23	30	23	30	23	30	23	29
24	31		*Dec.*	24	29	24	29	24	28	24	31	24	30	24	31		*July*	24	31	24	31	24	30
	Nov.	24	1	25	30	25	30		*Mar.*		*Apr.*		*May*		*June*	24	1		*Aug.*		*Sept.*		*Oct.*
25	1	25	2	26	31	26	31	25	1	25	1	25	1	25	1	25	2	25	1	25	1	25	1
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29	5	29	6	29	3	29	3	29	5	29	5	29	5	29	5	29	6	29	5	29	5	29	5
30	6	.....	.....	30	4	30	4	30	6	30	6	30	6	30	6	30	7	30	6	30	6	30	6
31	7	.....	.....	31	5	.....	.....	31	7	.....	.....	31	7	31	7	.....	.....	31	7	.....	.....	31	7

YELLOW BODIES

Retained corpora lutea (yellow bodies) are closely associated with, or cause, cessation of heat periods. It was felt that a study of the chemical and nutritive properties of corpora lutea might give some clue to this relationship. Consequently, yellow bodies of cows were obtained from slaughter houses, those from pregnant cows being kept separate from those from non-pregnant cows. The bodies thus obtained were dried in a vacuum oven at a low temperature and then ground in a mortar. The dried material was analyzed chemically, and the results of these analyses are given in Table 2.

TABLE 2.—Chemical Composition of Corpora Lutea (Yellow Bodies)

	Pregnant	Non-pregnant
	Per cent	*Per cent*
Dry matter	96.71	97.55
Protein	67.12	67.37
Fat	28.65	26.55
Saponification value	206.55	205.95
Unsaponifiable residue	55.00	57.26
Ash	5.17	5.39
Calcium	0.0539	0.0682
Phosphorus	1.2125	1.2540
Iron	0.0245	0.0553
Copper	0.0114	0.0107
Manganese	.....	.....

The only significant difference in chemical composition was found in the iron content, the material from non-pregnant cows being richer in this element than that from pregnant cows.

From both the pregnant and non-pregnant cows, corpora lutea were found to be excellent sources of vitamin A, the material from non-pregnant cows being somewhat more potent.

FEEDING

LOWER PROTEIN STANDARD FOR MILK PRODUCTION

Work done at this Station and similar work carried out at other research institutions have resulted in the formation of a new standard for the amount of feed protein required by the cow for milk production. This standard recognizes that an amount of digestible feed protein equal to 1.25 times the amount of protein which is being produced in the milk, in addition to the customary maintenance allowance, is adequate to provide for normal reproduction and for a reasonably liberal level of milk production and to keep the cow in good condition over long periods of time. This is in contrast to 1.75 times the protein content of the milk which was called for by the Haecker Standard and the still greater amounts demanded in others of the older standards. Uncertainty regarding the completeness with which feed protein could be transformed into milk protein and fear of what might be the effect on the cow of the long continued use of low-protein rations were chiefly responsible for the very high protein prescriptions of the past.

These points of uncertainty have been quite thoroughly studied in recent years so that the new standard, as yet unnamed, is really backed by more experimental evidence than any of the older standards.

Some investigators have recently gone as far as to say that there is no advantage to be gained from the use of protein in excess of the amount prescribed in this standard. Our own results indicate, however, that there is some advantage in the use of extra protein, up to about the level of the Haecker Standard. However, it becomes a question of the price of milk and of the premiums which must be paid for the higher protein grain whether the extra production will pay for the extra cost of the feed. Heavy-producing cows responded much more profitably to the high-protein feeding than those producing at a lower level.

Two Ohio Experiment Station publications dealing with this subject are Bulletin 389 and Bimonthly Bulletin, November-December, 1930.

DAIRY FEEDS WHICH TEND TO CAUSE ACIDOSIS

In the Fiftieth Annual Report it was shown that neither the heavy feeding of corn silage in connection with alfalfa hay and grain nor lactic or acetic acid in pure form, to the extent of 1.75 pounds per day, in connection with an otherwise normal ration caused any of the characteristic symptoms of acidosis in dairy cows. This work was followed by a similar study of the effect of the various common dairy feeds alone and in combination.

Exclusive grain feeding soon brought about a decidedly acidic condition of the cow, as judged by the urine analyses. The blood also showed evidence of an abnormal condition after 3 weeks on the exclusive grain feeding. The protein content of the grain did not seem important in determining the amount of this acidic effect.

A ration consisting exclusively of corn silage did not develop the signs of acidosis (low pH, very low bicarbonates, and very high ammonia in the urine).

Corn silage fed in connection with an acidosis-producing ration prevented or greatly delayed the development of the acidic condition. When corn silage was fed as the sole roughage over a period of several months, the bicarbonates of the urine were at a relatively low level, especially in the case of high-producing cows. The ammonia, however, was not especially high, and there was no other symptom to indicate an acidic condition.

Corn silage added to a ration which had produced an acidic condition slowly brought about a return to a more nearly normal condition.

All of the legume hays are highly alkaline in their effect and are very potent in correcting acidic tendencies of the other feeds.

Timothy hay, like corn silage, did not produce an acidic condition by itself but was not highly effective in neutralizing the acidosis caused by heavy grain feeding.

Bone meal, hydrated lime, and soda were each tried but did not seem particularly effective in overcoming the acidic effects of heavy grain feeding.

A more detailed account may be found in the Bimonthly Bulletin for January-February, 1931.

WHEAT AS A FEED FOR DAIRY COWS

A few years ago dairymen never thought of feeding wheat to dairy cows. In fact, the idea of feeding wheat seemed too absurd for even experimentalists, and, as a consequence, the period of low wheat prices, which started in 1930, found us with very little information on this grain as a feed for dairy cows.

A comparison of the chemical analyses of corn and wheat would lead to the conclusion that these two grains would be about equal in feeding value. However, it is only by actually feeding a substance that such factors as

palatability, digestibility, and physical effects on the animal can be determined. It is also conceivable that other factors, commonly referred to as "poisonous", may be discovered in a feeding trial. Before this experiment was started, in the fall of 1930, various rumors were heard about wheat feeding; namely, that wheat was not palatable, that it would cause cows to go off feed, and that it would "dry off" cows. It was also claimed that a poisonous substance was present in wheat, which sometimes was conducive to abortions. These rumors may have originated from some early Wisconsin[1] work in which wheat products only were fed. In the fall of 1930, even though wheat was comparatively cheap, many dairymen were hesitant about feeding it because of these reports.

EXPERIMENTS OF 1930-1931

Beginning on October 15, 1930, eight purebred Jersey and four purebred Holstein cows were divided as evenly as possible into two groups. Both groups were treated alike, with the exception that one received a grain mixture containing corn, while the other received a like mixture, with wheat replacing 75 per cent of the corn. The grain mixtures are tabulated here:

CORN MIXTURE		WHEAT MIXTURE	
Corn	400	Wheat	300
Oats	300	Corn	100
Bran	100	Oats	300
Linseed oilmeal	100	Bran	100
		Linseed oilmeal	100

Alfalfa hay and corn silage were fed to both groups. Grain was fed according to milk production, at approximately the Savage Feeding Standard.

The two groups of cows were fed the rations in two alternate periods of 75 days each, and eight of the 12 cows were fed for a third period of 75 days. The production while on the wheat ration was practically the same as during the corn feeding period. The cows tested slightly higher while on the wheat than while on the corn, but they gained less in body weight.

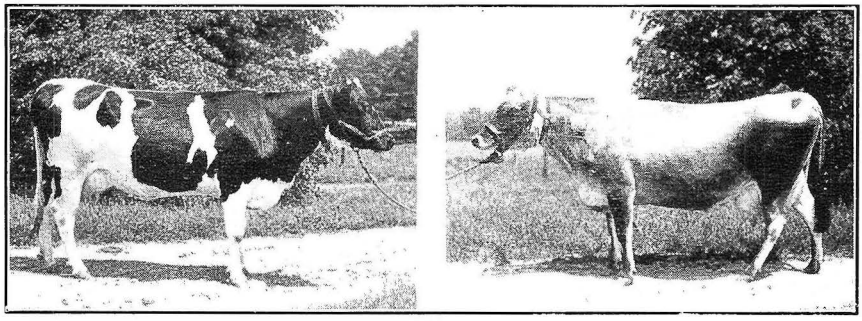

Fig. 4.—Marcella October De Kol 1170340 Mio Queen 631834

Marcella October De Kol 1170340, highest producing Holstein in the experiment. Average monthly production:

On the wheat ration, 1098.9 lb. milk, 50.9 lb. fat, test 4.63%
On the corn ration, 1194.0 lb. milk, 52.6 lb. fat, test 4.40%

Mio Queen 631834, highest producing Jersey in experiment. Average monthly production:

On the wheat ration, 1009.8 lb. milk, 50.8 lb. fat, test 5.03%
On the corn ration, 1059.6 lb. milk, 50.9 lb. fat, test 4.80%

[1]Wisc. Agr. Exp. Sta. Res. Bull. 17, 1911.

Continuous wheat feeding.—Another part of the wheat feeding experiment that may be of practical interest was the continuous feeding (not reversal) of a wheat mixture to a group of 11 cows in various stages of lactation. These cows were fed for 7 months on a grain mixture consisting of 400 pounds wheat, 300 pounds oats, 100 pounds bran, and 200 pounds linseed oilmeal. This concentrate mixture was fed with mixed hay as the only roughage.

The cows produced normally on this ration and eight of the 11 dropped normal calves. The other three were carrying calves at the end of the experiment. The live weights of these cows were not quite up to the usual standard of previous lactations. This was especially true of those in heavier production. The continuous feeding of this grain mixture containing 40 per cent of wheat resulted in no ill effects.

EXPERIMENT OF 1931-1932

The fall of 1931 found wheat selling for the very low price of 36 cents per bushel. It also found milk selling at a low figure and the protein feeds comparatively high in price.

A grain mixture containing approximately 50 per cent of wheat was compared with the regular herd mixture which was used in the previous trial. The wheat mixture contained in addition only corn and oats, making it a home-grown mixture, with the exception of the salt and bone meal. These rations are shown in Table 3.

TABLE 3.—Rations Used

	Wheat	Check	Digestible crude protein
	Lb.	*Lb.*	*Per cent*
Corn	250	400	7.12
Wheat	500	.....	8.37
Oats	250	300	11.90
Bran	.....	100	12.62
Linseed oilmeal	.....	100	32.04
Bone meal	20	.....	4.29
Salt	10	9	.....
Digestible crude protein	8.76	11.97	.....
Roughages:			
Alfalfa hay (2nd cutting)	.....	.....	11.23
Corn silage	.....	.....	1.38

This experiment was conducted on the same basis as that of the previous year. The cows ate the wheat mixture very well and seemed to do very nicely on it, the production being only very slightly under that of the check cows. The four high-producing cows in this experiment averaged, per cow per month, for the 7 months of the experiment, 1049.6 pounds of milk and 48.4 pounds of butterfat on the wheat ration and 1087.5 pounds of milk and 48.9 pounds of butterfat on the corn ration. The average test on the wheat ration was 4.6 per cent and on the corn ration, 4.5 per cent. This group of four cows was composed of the high Holstein and the high Jersey cow in each of the two groups.

The results obtained with these four cows are a very strong indication that the two grain mixtures were practically equivalent. If there were any unfavorable effects from the wheat, they should have shown up with these cows, because they ate liberal quantities of grain.

Another group of cows was fed continuously on the 50 per cent wheat ration throughout the winter feeding period. These cows did very well.

Butter manufactured from the cream produced by the cows on the 50 per cent wheat ration was somewhat inferior to that from the cows on the check ration. This difference varied somewhat with the various lots of cream. Swiss cheese was also made from the milk produced on the two different rations. There was some rumor that Swiss cheese could not be made from the milk of cows fed wheat, but the Swiss cheese made from the milk of cows receiving a home-grown ration containing 50 per cent wheat was of good quality. The accompanying photograph shows a cross section of the cheeses. This manufacturing work was conducted at the Ohio State University, under the direction of R. B. Stoltz, of the Department of Dairy Technology.

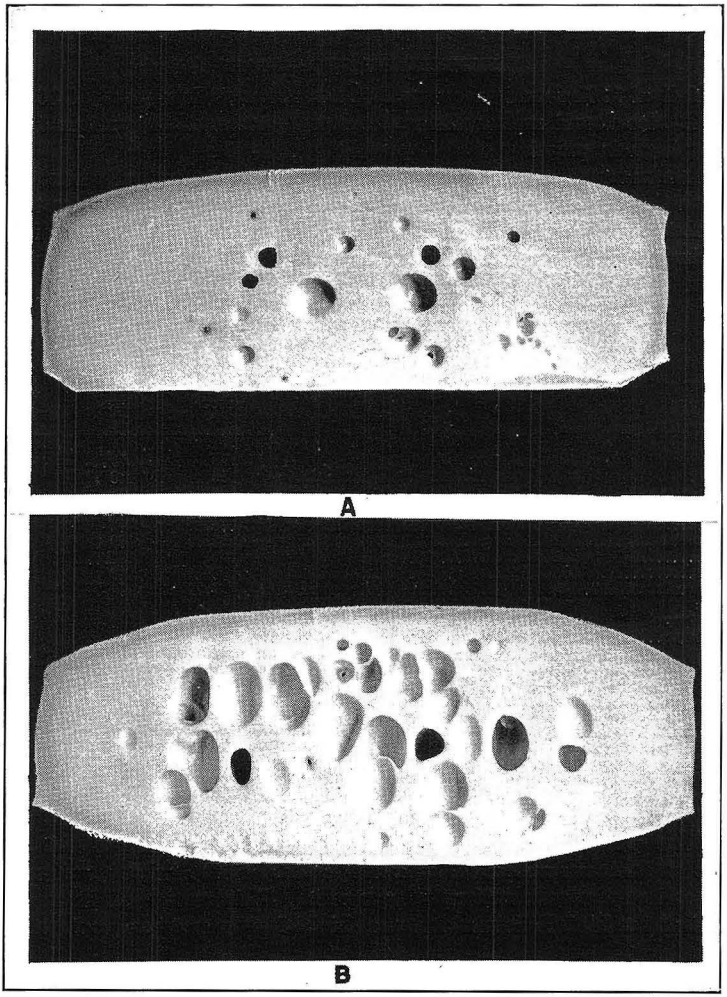

Fig. 5.—Swiss cheese made from milk produced on the two rations

A. From check ration containing no wheat.
B. From home-grown grain mixture, containing approximately 50 per cent wheat.

In order to give wheat a still more drastic trial, two Jersey cows were started on a ration containing alfalfa hay as the sole roughage and ground wheat mixed with 2 per cent steamed bone meal as the grain mixture. One of these cows, No. 314, produced in 365 days 9,824.3 pounds of milk and 474.4 pounds of butterfat. She ate nearly 2 tons of wheat in the year. The other cow, naturally a low producer, made 274.3 pounds of butterfat in 278 days. An early breeding caused this short lactation. This work should not be taken as an unconditional recommendation for wheat feeding.

Biological assay of the butterfat from the cows on the grain mixture of 50 per cent wheat showed that this fat was not as good a source of vitamin A as the butterfat from the cows receiving the check ration. The butterfat from the cows fed wheat as the only grain was quite deficient in vitamin A.

SUMMARY

When the price of wheat warrants, due to low prices or to low grade, this grain may be safely substituted for corn or may be included in the grain up to 40 per cent of the mixture. Larger amounts may possibly be fed for short periods, but, as a general rule, extremes of feeding are to be avoided.

See Bimonthly Bulletins for November-December, 1931, and for September-October, 1932.

THE RELATIVE FEEDING VALUE OF GROUND SOYBEANS AND SOYBEAN OILMEAL

A direct comparison was made between these feeds at the Hamilton County Experiment Farm during the winter of 1931-1932.

The grain mixture used in one case contained 25 per cent of ground soybeans; the other grain mixture, 25 per cent of soybean oilmeal. The remainder of the grain mixture in each case consisted of equal parts of corn-and-cob meal, ground oats, and ground wheat.

About 3 per cent (900 pounds) more of 4% milk was produced during the periods when the soybean oilmeal was fed, which brought an increased return of $15.31.

The local valuation of soybeans was 50 cents per bushel, or 83 cents per hundredweight. A grinding charge of 10 cents per hundredweight brought the value of the soybeans to 93 cents per hundred pounds. The soybean oilmeal cost an average of $1.40 per hundred pounds during this period, making the average difference in price 47 cents per hundred. The extra cost of the soybean oilmeal over the ground soybeans was $16.51.

This work agrees with former work from this department in showing a slight superiority for the soybean oilmeal when fed in equal quantity. It also shows that the ground soybeans may be used to equally good advantage when the price margin between the two is comparable to that prevailing during this experiment.

COCOANUT MEAL FOR DAIRY COWS

Except as an ingredient of mixed feeds, copra meal (cocoanut meal) has never been used extensively as a dairy feed in Ohio until quite recently. Within the past 2 years, at least two large-scale Ohio oil crushers have been offering cocoanut meal in the open market. Much interest has been aroused as to its feeding value compared with the more familiar high-protein supplements. Because it has a much lower protein content than most of the other oilmeals, it can best be compared with a mixture of the oilmeals and corn and oats having about the same protein content.

Such a comparison was made in the dairy herd at the Hamilton County Experiment Farm during the winter of 1930-1931. The rations shown in Table 4 were compared.

TABLE 4.—Ingredients of the Grain Rations Compared

	Basal or check ration	Cocoanut meal ration
	Lb.	*Lb.*
Corn-and-cob meal	250	200
Ground oats	250	200
Ground wheat	250	200
Cottonseed meal	125	50
Linseed oilmeal	125	50
Cocoanut meal	none	300
Total	1000	1000
Per cent of digestible crude protein	14.07	13.66
Per cent of total digestible nutrients	76.22	76.94

Milk production, when reduced to its equivalent in 4% milk, was about 3 per cent greater on the ration containing the cocoanut meal. This indicates that cocoanut meal is a desirable dairy feed and that its cash value should be about the same as that of a mixture containing 25 per cent each of choice cottonseed and linseed oilmeals and 50 per cent of the farm-grown grains, corn or wheat and oats.

Some investigators have apparently obtained an increase in the fat content of the milk produced by feeding cocoanut meal. This point is stressed in some advertisements for cocoanut meal. However, no such increase in fat content was obtained in this experiment.

For greater detail see the Bimonthly Bulletin for September-October, 1931.

MANAMAR FOR GROWTH AND MILK PRODUCTION

The experiment consisted in feeding a group of heifers on a grain mixture containing 10 per cent Manamar (fishmeal, kelp, and limestone) from the time the heifers were 6 months of age until their second calving. A similar check group of heifers was fed in like manner on the same grain mixture, with the exception that linseed oilmeal was substituted for Manamar.

TABLE 5.—Manamar Versus Linseed Oilmeal

First lactation figures		Check heifers	Manamar heifers
Breedings per calf	Jerseys	1.2	1.2
	Holsteins	1.3	1.2
		Females	
Weight of all calves dropped (lb.)	Jerseys	50	60
	Holsteins	108	90
		Males	
	Jerseys	52	60
	Holsteins	96	95
Increase in height at withers between first and second calving (in.)	Jerseys	+ 0.50	− 0.50
	Holsteins	+ 0.70	+ 0.87
Increase in liveweight between first and second calving (lb.)	Jerseys	107	169
	Holsteins	300	218
Production of 4% milk (lb.). (Average per month—1st 160 days)	Jerseys	794.6	814.6
	Holsteins	713.8	685.1
Both breeds (average production)		754.2	749.9

In brief, there was no outstanding difference between the two groups (Table 5). These results may be interpreted to mean that, for this experiment, the check ration containing the oilmeal met the nutritional needs of the heifers and that those additional factors furnished by the Manamar, such as minerals, iodine, vitamin D, and possibly other factors, were not needed. This point is probably best illustrated in the matter of reproduction, which was so near 100 per cent in the check group that there was little chance for improvement by the Manamar ration.

TWO YEARS' FEEDING OF MANAMAR TO A HERD OF DAIRY COWS

The dairy herd at the Belmont County Experiment Farm was used in making this test. At the start of the experiment, the herd, consisting of 14 cows, was divided as evenly as possible into two groups. Both groups were treated alike in all respects, with the exception that one group received a grain mixture containing 10 per cent Manamar. The check group received practically the same grain ration except that a mixture of cottonseed meal, bone meal, and salt was used instead of Manamar. This herd was fed and managed as an ordinary, good, farm herd. Grain was fed winter and summer. The cows received mixed hay and corn silage in winter and pasture in summer.

The herd was positive to the test for abortion.

The history of this herd for the 2 years previous was such that a comparison of "Before" and "After" could be made, as well as a comparison of the two groups during the time of the experiment.

A careful analysis of the figures shows that the Manamar ration was practically the equivalent of the check ration for milk production. Although the breeding history of the cows on Manamar was a little better than that of the check cows, the data that can be obtained from 14 cows in 2 years are too limited to warrant a definite statement. The work does show that such things as abortions, milk fever, and udder trouble can happen with cows fed Manamar. The milk from the Manamar group contained 0.17 milligrams of iodine per quart; whereas no iodine could be found in that from the check group.

A more complete account is given in the Bimonthly Bulletin for March-April, 1932.

SILAGE WITHOUT HAY FOR DAIRY COWS

The protein in the dairy ration is generally the expensive item. If a dairyman can grow a large part of his own protein he can effect a saving. The legume hays offer the best opportunity for accomplishing this. Soybeans, an excellent hay for dairy cows, would no doubt be raised more extensively if this crop were not so difficult to cure and if it did not mature at a season of the year when curing weather is rather limited.

A desirable way to handle the soybean crop is to put it into the silo with corn. In 1923, at this Station[2] soybeans were ensiled with corn at the rate of 1 pound of soybeans to 1.5 pounds of corn (calculated on dry basis). In a double reversal feeding trial, the soybeans as silage proved to be the equivalent of soybeans as hay. No dry roughage was fed to the silage group of cows. Although the first period of this experiment lasted for 2½ months, the question may well be raised, could the cows get along all winter without hay?

[2]Bimonthly Bulletin for September-October, 1926, p. 178.

On the 25th of August, 1932, soybeans were ensiled with corn at the rate of 2 parts of soybeans to 1 part of corn, by weight (calculated to dry basis). When putting soybeans into the silo, even with corn, they should be partly cured. The soybeans in this case were dried to a 57 per cent dry matter content. This is drier than necessary or desirable. However, a palatable silage resulted. This silage on the dry basis contained 14 per cent total protein, or approximately the equivalent of good alfalfa hay.

Starting on the 12th of November, 1932, this silage was fed to a group of five cows as their sole roughage. A low-protein grain mixture was also fed. Approximately two-thirds of the protein of the entire ration came from the silage. The cows ate this silage very well and appeared to remain in good condition. The average monthly production was 872 pounds of milk and 41.1 pounds of butterfat. Unfortunately, the supply of this high-protein silage was exhausted after feeding for 101 days. The cows were then changed to ordinary corn silage as the entire roughage. With this silage they received a different grain mixture, one of high-protein content and one containing 1 per cent steamed bone meal and 1 per cent limestone. Considering the advance in lactation, the cows did as well on this ration as they had on the preceding ration. Because of the large amount of purchased protein concentrates this ration was more costly. Another group of cows was fed the corn silage, with a high-protein-concentrate grain mixture, containing bone meal and limestone, continuously for a period of 5½ months, or practically the winter feeding season. The cows on this all-corn-silage roughage did remarkably well, with an average monthly production of 895 pounds of milk and 43.4 pounds of butterfat. These cows also kept in good condition and appeared to be normal.

On several occasions during the course of these trials, the urine from the individual cows was tested for those factors known to indicate an acid, or deranged, condition of the body. These tests failed to show any abnormality.

Although this may be an extreme method of feeding, it points to the possibility of using silage as the sole roughage and of making a greater use of soybeans in the silo. It also suggests that the liberal feeding of corn silage as the only roughage is not harmful in itself for a 5-month period, if the ration contains an adequate amount of protein and minerals.

The results of this experiment are summarized in Table 6.

TABLE 6.—Summary of Production of Cows on Silage-without-hay Rations

	Group I		Group II
	Soybean-corn silage Nov. 12–Feb. 21	Corn silage Feb. 22–Apr. 30	Corn silage Nov. 12–Apr. 30
Days in period	101	68	169
Milk production per month, Lb.	872.7	782.4	895.2
Butterfat production per month, Lb.	41.1	38.0	43.4
Butterfat test, Per cent	4.71	4.86	4.84
Feed consumption:			
Average daily silage, Lb.	49.6	56.5	59.0
Average daily grain, Lb.	10.0	8.9	9.4
Refuse, Per cent	1.4	0.9	0.8
Silage intake per cwt. live weight, Lb.	4.66	5.05	5.76
Silage dry matter intake per cwt. live weight, Lb.	1.61	1.54	1.75
Liveweight gain per month, Lb.	18.0	10.5	16.0

OTHER USES FOR THE SILO THAN STORING CORN CROP

The silo is quite generally recognized as a most practical and efficient means of storing the corn crop for feeding dairy cows. Numerous small-scale experiments and a limited number of experiments on a practical scale have suggested that it may often be advisable to make use of the silo in storing other crops. These data are supported in most cases by experiments and practical experience in other parts of the world where corn does not hold so predominant a place in the cropping system as it does in Ohio.

Corn stover was successfully ensiled with a volunteer crop of green oats at the rate of one pound of the stover to 4 pounds of the immature green oats in the fall of 1931. A silage of good quality, much better than ordinary stover silage, resulted. This suggests the possibility in emergencies of ensiling stover, not in demand for feeding, with beet tops, green oats, or Sudan grass, or, in general, the mixing of stover, straw, or hay with a green crop to secure a mixture of the right dry matter content (about 25 to 30 per cent) for making silage.

A mixture of nearly ripe wheat and green clover was ensiled in a small experimental silo in 1932. An excellent and highly palatable silage resulted. Green oats and green wheat have also been made into good silage. This suggests particularly the advantage which might be gained by ensiling a badly lodged or otherwise damaged crop of these grains which, in such condition, would make good silage but only an inferior quality of grain.

Timothy, alfalfa, clover, and soybeans, crops usually grown for hay, may also be successfully ensiled when weather conditions prevent their successful curing as hay. The legume hays should preferably be ensiled in mixture with other crops high in carbohydrates, such as corn, wheat, oats, or timothy. When ensiled alone, they should first be partly dried.

There is still much need for study regarding these kinds of silage.

SUDAN GRASS FOR JULY AND AUGUST PASTURE

Experience has shown that very little dependence should be placed on permanent pasture for dairy cows during July and August. For best results it is necessary to feed some additional roughage during this period. Silage has been quite strongly advocated for this purpose. Some dairymen resort to soiling crops. However, the daily work involved in cutting and getting this heavy, green feed to the cows becomes quite a burden. Pasturing a crop that would give a continuous growth during this period would appear to be preferable to a soiling system. Sudan grass seems to be a crop that answers this need.

At this station, during the summer of 1932 three heavy-producing Holstein cows were pastured for part of the summer on a small patch of Sudan grass close to the dairy barn. On an acre basis, this crop afforded 215 cow-pasture days, with a total production of 11,154 pounds of milk and 362 pounds of butterfat. The cows were fed grain at the rate of one pound to every 4 pounds of milk produced. At irregular intervals the cows were changed to a much larger field of permanent pasture in order to give the Sudan grass a chance to "pick up". While on the permanent pasture the daily production of these cows was 47.7 pounds of milk, as compared with 51.9 pounds on the Sudan grass. In addition, supplemental roughage feeding was necessary while the cows were on the permanent pasture.

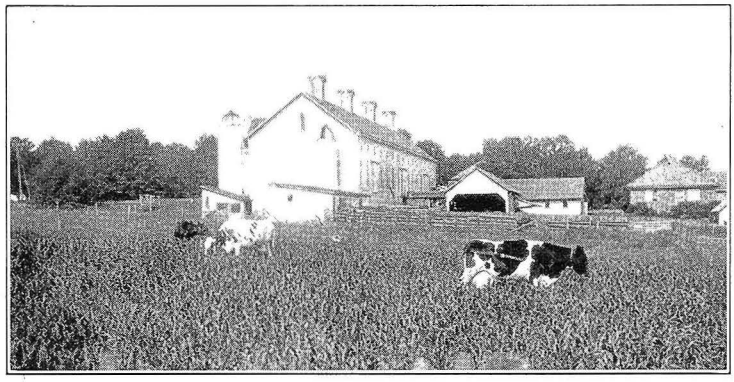

Fig. 6.—Cows pasturing in Sudan grass in August when other pastures are dry and brown

The days and dates of the pasture periods are given in Table 7. The average daily milk production for each cow is also given in this table. It is interesting to note the increase in production in the periods when the cows were on the Sudan pasture and the decrease in the following periods on blue grass. The average butterfat test was 3.25 per cent on the Sudan grass and 3.26 per cent on the blue grass. In other words, there was practically no difference in test.

TABLE 7.—Average Daily Production of Milk, with Dates of Pasturing

Type of pasture	Date	Days	Cow 276 Pounds of milk daily	Cow 397 Pounds of milk daily	Cow 343 Pounds of milk daily	Cow 391 Pounds of milk daily
Blue grass	June 16–June 22	7	58.2	59.6	46.2	.....
Sudan grass	June 23–July 5	13	59.7	63.3	47.9	.....
Blue grass	July 6–July 18	13	52.4	57.3	44.1	.....
Sudan grass	July 19–Aug. 2	15	57.0	56.7	47.7*	43.2*
Blue grass	Aug. 3–Aug. 16	14	50.6	48.1	.....	38.0
Sudan grass	Aug. 17–Aug. 23	7	50.7	52.2	.....	39.8
Blue grass	Aug. 24–Sept. 4	12	47.6	43.6	.....	35.7
Sudan grass	Sept. 5–Sept. 12	8	48.3	50.5	.....	37.0

*Partial periods.

The field which was used in this work was not unlike those found on many farms. It was a small lot near the barn used mostly as an exercise ground for young cattle. It had furnished very little pasture for several years.

Sudan grass has provided satisfactory midsummer pasture on the Hamilton County Experiment Farm for 4 years.

See Bimonthly Bulletin for March-April, 1933.

SUDAN GRASS CULTURE

Sudan grass was originally a tropical plant and, therefore, should be planted only after the soil has warmed up, or shortly after corn planting time. Since it is ready for pasture in 4 or 5 weeks after planting, later seeding may be made for this purpose in an emergency. For hay, however, July 15 is about

the latest date of seeding with any prospect of getting a crop before frost. When planted early, some pasture may be obtained following the removal of the hay crop, but seldom is it possible to obtain two hay crops in one season in Ohio.

A good seedbed should be prepared by thorough disking or plowing, preferably the latter, and it should be well firmed—a loose seedbed is highly objectionable. Sudan grass cannot compete with rapidly growing weeds; therefore, clean land should be used if possible. If not, then a week or two of fallow cultivation to destroy the first weed crop before planting the Sudan grass is desirable.

Sudan grass may be sown with a grain drill, using the wheat feed and setting the drill to sow about 2 pecks of wheat. This will sow about 20 to 25 pounds of Sudan grass seed to the acre. If the drill sows too much seed, some screened, cracked corn may be mixed with the seed to increase its bulk. The disc-type alfalfa or grass seed drill is ideal for sowing Sudan grass seed. The large side of the feed cup should be used. The seed may also be broadcast and harrowed in, but the rate of seeding should be increased slightly.

The seed should be covered shallow—½ to 1 inch deep on heavy soils and 1 to 2 inches on loose, sandy, or highly organic soils which do not crust or dry out easily on the surface.

If the seedbed is dry, rolling or cultipacking after sowing the seed will hasten germination.

Sudan grass may be cut for hay from the time it is well headed until the seeds are in the soft dough stage. The best quality hay is that from the early harvest. Sudan grass cut for hay requires somewhat longer curing in the field than clover or timothy, since the coarser stems dry slowly. Sudan grass is killed with the first heavy frost in the fall. Under certain circumstances when the growth has been checked by frost, the plants develop a poison (prussic acid) which is very toxic to livestock other than hogs. Therefore, after frost, it should be pastured with caution. The hay, apparently, is free from this danger.

L. E. Thatcher, Associate in Field Crops
March-April, 1933, Bimonthly Bulletin

GRAIN FEEDING ON PASTURE

Experiments extending over two pasture seasons in which grain mixtures of 12 per cent and 20 per cent total protein content were compared showed that the lower protein mixture consisting of 50 per cent corn and 25 per cent each of oats and bran gave practically as good results as did the more expensive mixtures of higher protein content.

A single season's work at the Hamilton County Experiment Farm compared two different rates of grain feeding: (a) One pound of grain to 4 pounds of milk and (b) one pound of grain to 8 pounds of milk. The pasture, including Sudan grass in midsummer, was good throughout the season, and the herd was producing at the relatively low level of 27.13 pounds of butterfat

per month. The maximum for any cow was 42 pounds per month. Under these conditions the difference in the rate of grain feeding apparently had no influence on the production.

With less favorable pasture conditions or cows at a higher level of production, these results might have been different.

SOLUBLE BLOOD FLOUR VERSUS SKIMMILK POWDER FOR CALVES

Several years ago the New Jersey Experiment Station devised a system of raising calves which reduced the labor and the amount of whole milk required to a very low point. Essentially, the system consisted of feeding calves not more than 3 quarts of milk a day for the first 3 weeks. At the end of that time the whole milk was diluted with water in increasing amounts from day to day so that when the calves were 30 days old they were receiving water, alfalfa hay, and a grain mixture containing 12½ per cent of soluble blood flour. It was claimed that good calves were grown under this system. This somewhat radical departure from the usual methods of raising calves made it seem desirable to try out the system under Ohio conditions before recommending it to Ohio farmers.

After considerable preliminary work at Wooster, an extensive experiment was begun with heifer calves dropped in the Holstein herd at the Mansfield Reformatory dairy. As the calves were dropped they were assigned to one of four groups. In the first group, the New Jersey system of feeding was followed, with one exception—Instead of limiting the calves to 3 quarts of whole milk daily they were fed one pound of whole milk for each 10 pounds of live weight during the first 3 weeks. In Group II, the calves were handled and fed exactly as in Group I, except that 12½ per cent of skimmilk powder was used in the grain mixture instead of 12½ per cent of soluble blood flour. Group III differed from Groups I and II in that the substitution of skimmilk powder for soluble blood flour was made on a protein basis.

Group IV was raised on liquid skimmilk in the usual way.

The grain mixtures used are given below:

	Group I	Group II	Group III	Group IV
Yellow corn meal	100	100	56	100
Ground oats	150	150	95	100
Wheat bran	50	50	50	100
Linseed oilmeal	50	50	82.5	50
Soluble blood flour	50	.....	.....	.....
Skimmilk powder	.....	50	116.5	.....
Steamed bone meal	4	4	4	.....
Limestone	4	4	4	.....
Salt	4	4	4	1.75
Total protein, Per cent	22.9	17.2	22.9	15.6

The calves were weighed and measured once a week during the 6-month feeding period and on 3 consecutive days at the close of the trial. A summary of the results obtained is given in Table 8.

TABLE 8.—Skimmilk Powder, Soluble Blood Flour, or Liquid Skimmilk for Calves

	Group I	Group II	Group III	Group IV
Number of calves	13	15	14	14
Initial weight, Lb.	86.0	90.4	93.9	89.3
Final weight (6 months), Lb.	374.0	355.7	368.9	448.5
Gain in weight, Lb.	261.0	265.3	275.0	359.2
Average daily gain, Lb.	1.42	1.45	1.50	1.95
Initial height, In.	29.17	29.15	29.75	29.32
Final height, In.	39.53	39.68	40.36	41.88
Gain in height, In.	10.36	10.53	10.61	12.56
Feed consumption, Lb.:				
Whole milk	199.2	214.9	206.9	196.0
Skimmilk				2322.9
Grain	558.2	654.1	677.9	597.1
Feed cost:				
Whole milk	$1.99	$2.15	$ 2.07	$ 1.96
Skimmilk				3.48
Grain	6.03	7.65	12.47	4.60
Total (minus hay)	8.02	9.80	14.54	10.04
Feed cost per pound gain	0.0307	0.0369	0.0529	0.0280
Feed cost per inch gain	0.774	0.931	1.37	0.799

Cost figures used:
(Per cwt.)

Whole milk	$1.00
Skimmilk	0.15
Grain No. 1	1.08
Grain No. 2	1.17
Grain No. 3	1.84
Grain No. 4	0.77

The calves in each group gained at least as well as the average usually accepted for Holstein calves. The animals in Groups I, II, and III were pot-bellied and shaggy during the second and third months, but by the time they were 6 months of age they were quite fit.

It is apparent from the data in Table 8 that skimmilk powder can be substituted on a pound for pound basis for the soluble blood flour in the New Jersey calf meal, in spite of the fact that such a substitution reduces the total protein from 22.9 per cent to 17.2 per cent.

The calves in Group III apparently grew at a slightly greater rate than did those in Groups I and II, but the difference cannot be shown to be statistically significant. It can be concluded with certainty that under the system of feeding employed it did not pay to increase the skimmilk powder content of the grain mixture from 12½ to 28 per cent.

The liquid skimmilk calves (Group IV) were outstandingly superior in appearance throughout, and, from the data in Table 8, it will be seen that they grew much faster at less cost per unit of gain in weight than did the calves in any of the other lots.

This experiment demonstrates that, when no skimmilk is available and it is desired to feed calves as little whole milk as possible, the New Jersey system or the modifications of it used here can be employed. However, until data on the subsequent development of the calves can be obtained and until further modifications have been tried, our unqualified endorsement must be reserved.

The great superiority of the group receiving liquid skimmilk emphasizes the value of this product in a calf feeding program. It should be pointed out that the calves in Group IV were more liberally fed than necessary.

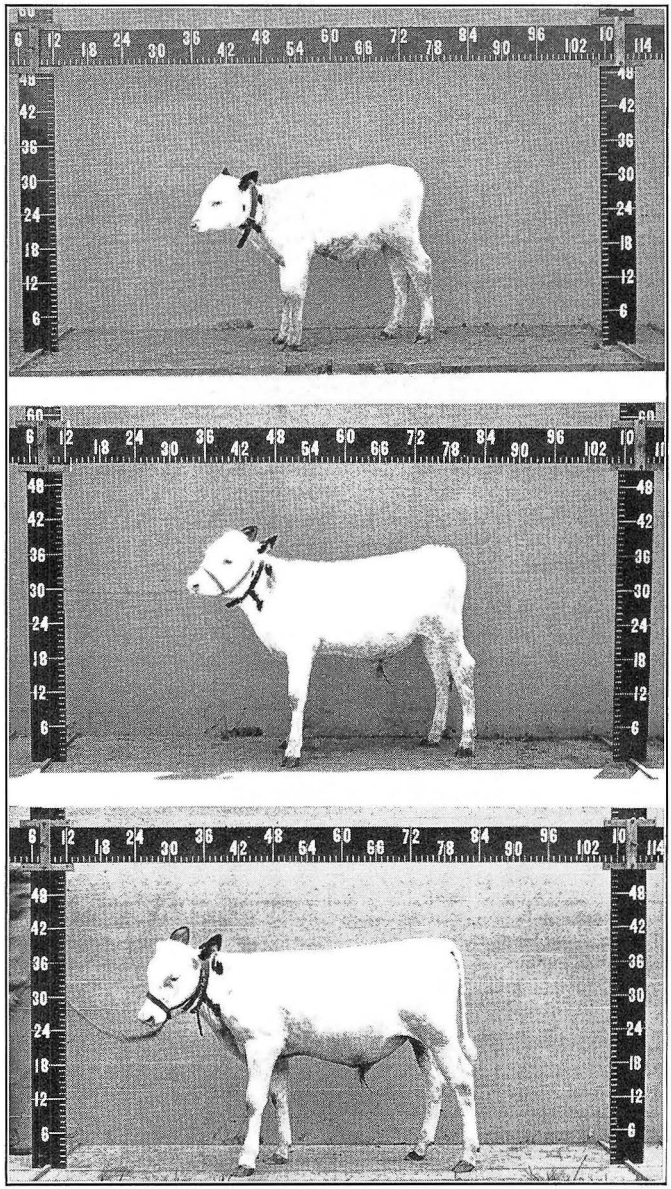

Fig. 7.—Calf M 345 at 2 months, 4 months, and 6 months of age. This calf received no milk from the time it was 30 days old

MILK STUDIES

THE DEFICIENCIES OF AN EXCLUSIVE MILK RATION FOR CALVES

Three calf feeding trials have been conducted with Holstein male calves during the past 2 years to determine the effects of an exclusive whole milk diet, whole milk with inorganic iron and copper supplements, and a normal system of raising calves, upon the general health, rate of growth, and the erythrocyte and hemoglobin content of the blood. Each feeding trial lasted approximately 8½ months.

All calves were weighed at 2-week intervals, and red cell counts and hemoglobin determinations were made.

Lot I calves, receiving the exclusive whole milk diet, weighed on the average at the end of the experiment 363 pounds. Lot II calves, receiving the whole milk with copper and iron supplements, weighed on the average 430 pounds; whereas Lot III calves, receiving the normal calf ration, weighed on the average 623 pounds.

Nutritional anemia was produced in those calves receiving whole milk exclusively. The additional iron and copper supplements maintained the erythrocytes and hemoglobin at a high level.

Some of the calves in Lots I and II exhibited external symptoms of rickets. These observations were confirmed by blood studies and, after slaughter, by breaking strengths of the cannon bones.

These experiments demonstrate that calves, like several other species of animals, will develop nutritional anemia if kept for too long a time on nothing but milk. They also confirm previous observations that copper and iron are essential for blood regeneration. In addition, they show that the calf requires vitamin D. This factor is usually supplied in hay that has been sun-cured.

THE COMPOSITION OF MILK AS AFFECTED BY THE AMOUNT OF PROTEIN FED

A thorough study has been made of the figures representing the detailed analyses of more than 1000 samples of milk obtained over a period of several years from cows fed widely different amounts of protein, the rations ranging from 1:2 to 1:13 in nutritive ratio.

None of the major constituents of the milk (fat, lactose, ash, and protein), as ordinarily determined, was perceptibly increased or decreased by even the most radical change in the protein content of the ration. The properties of the milk fat and the character of the milk protein were also unaffected by these changes.

One minor group of constituents of the milk, often referred to collectively as non-protein nitrogen, is the only portion which appears to be regularly affected by the level of protein feeding. This non-protein nitrogen ordinarily comprises about 5 per cent of the total nitrogen of the milk.

There was nearly twice as much non-protein nitrogen in the milk of the cows receiving the 1:2 ration as in the milk from those receiving the 1:13 ration. Of the several materials in this group, some of them unknown, urea was the one most affected by the level of protein feeding, the amount being eight times as much in the milk from the 1:2 as in that from the 1:13 ration.

This study is presented in Bulletin 515.

RAW VERSUS PASTEURIZED MILK

It has been known for some time that pasteurization tends to destroy the vitamin C in milk, but the decreased amount of vitamin C in pasteurized milk is commonly counterbalanced by the use of fruit juices, tomato juice, vegetables, and tubers. However, little direct evidence was available as to the effect of pasteurization on other vitamins contained in raw milk. Consequently, a study of this question was made. It was found that pasteurization (heating to 145° F. for 30 minutes) destroyed some of the vitamin B but had no effect on vitamins A, G, and D. Since milk is only a fair source of vitamin B at best and since vitamin B is readily available in many other foods, including those adapted to infant feeding, it is felt that the somewhat diminished amount of vitamin B in pasteurized milk offers no serious problem.

Fig. 8.—Litter mates after 8 weeks on (above) raw milk and (below) pasteurized milk. Note lack of color in the eyes. Both rats have severe nutritional anemia.

Some beneficial effect might be attributed to pasteurization, inasmuch as it was found that there was a tendency for the curd tension to be slightly decreased. Low curd tension and high digestibility have been found to be correlated.

Rats on pasteurized milk exclusively did not develop nutritional anemia more rapidly than those on raw milk exclusively. When the exclusive milk

diets were supplemented with copper and iron to prevent anemia, the rate of growth over a 12-week period was not significantly greater on raw milk than on pasteurized milk.

It was also found that calcium and phosphorus were as well utilized on pasteurized milk as on raw milk. This was based on the fact that no difference was found in the ash content of the femurs and entire bodies or in the calcium and phosphorus content of the entire bodies of rats fed either raw or pasteurized milk exclusively.

Details of this study will be found in Bulletin 518.

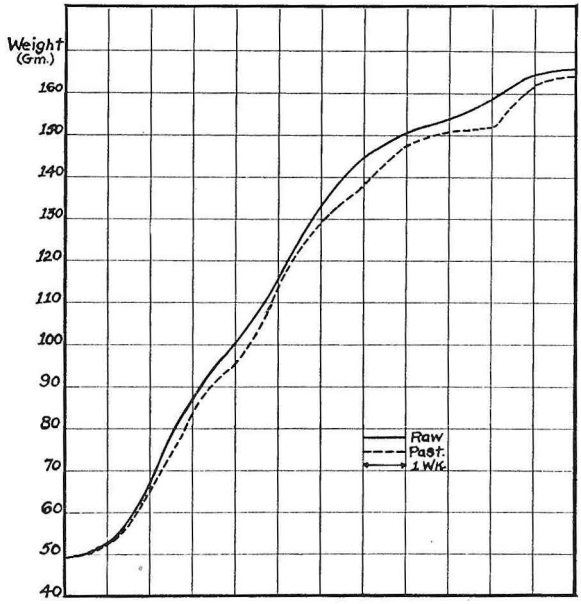

Fig. 9.—Rate of growth on raw and pasteurized milk when the factor of anemia was eliminated by adding iron and copper to the milk. The curves are composites of 12 pairs.

VITAMIN-D MILK

Since vitamin D is necessary for proper bone development, children have a rather high requirement for this vitamin. This is evidenced by the fact that many children develop the disease known as rickets. Natural foods, including milk, do not contain enough vitamin D to meet the needs of children for this factor. Consequently, cod-liver oil, viosterol, and ultra-violet light (sunshine) have been depended upon to prevent or cure rickets in children. In spite of the availability of these materials rickets is still quite prevalent. Because of this, it was thought that if some common, cheap article of food like milk could be increased in vitamin-D content considerable benefit might be obtained. It seemed that the most logical way to do this would be through feeding cows materials rich in vitamin D.

Irradiated ergosterol (viosterol), the most potent source of vitamin D, was first tried for this purpose. It was found that the vitamin-D content of milk could be increased many times by feeding cows rather large quantities of this material. One pint daily of milk produced under such feeding conditions brought about slow healing in the bones of children suffering from rickets. The cost of feeding cows irradiated ergosterol was too great to warrant its use for this purpose.

The next vitamin-D carrier tried was a cod-liver oil concentrate (Vitex). This material was also effective in increasing the vitamin-D content of milk many times, but it, too, was too expensive.

Irradiated yeast was then tried and found to be very effective for this purpose at a reasonable cost. It is now possible to use irradiated yeast to increase the vitamin-D content of milk at an additional cost of one-half cent a quart. The procedure consists of adding a prescribed amount of yeast (according to milk production) to the grain allowance at each feeding or of mixing the yeast with the grain mix, which automatically allows for production when grain is fed on this basis. Milk produced by such a feeding program has been found, in experiments with babies, to prevent or cure rickets.

The production of vitamin-D milk through feeding cows irradiated yeast probably is of greatest interest to producer-distributors. Many operators are now receiving a substantial premium for such milk.

Vitamin D can be added to milk directly by exposing the milk to ultra-violet light or by adding a cod-liver oil concentrate. These two methods are being used chiefly in milk plants where large volumes of milk from many different sources are handled.

Before engaging in vitamin-D milk production it would be well to determine if there will be a suitable outlet for it and whether or not health officials will sanction it.

THE EFFECT OF FEEDING YEAST TO COWS ON THE VITAMIN-B AND VITAMIN-G CONTENT OF MILK

Two separate experiments on feeding dried yeast to cows were made. In the first, ½ pound of dried yeast was fed to each cow daily as a supplement, replacing an equivalent amount of linseed oilmeal protein. Good quality alfalfa hay and corn silage were fed, in addition to a good grain mixture. Representative composite samples of milk were obtained during the control and yeast-feeding periods. These were skimmed and the skimmilk dried in a hot-air chamber and ground to a powder.

In the second experiment, the same procedure with respect to feeding the cows and obtaining the milk samples was followed, except that, instead of ½ pound of dried yeast, ¾ of a pound was fed daily as an ingredient of the grain mixture.

The samples of skimmilk powder obtained in these two experiments were fed to rats in order to determine the amounts of vitamins B and G they contained. It was found that the feeding of yeast to cows did not increase the vitamin-B content of the milk and increased the vitamin-G content slightly. Since yeast is one of the most potent sources of vitamin B known, it is felt that it is not practically possible to increase the amount of this factor in milk through feeding.

See Bimonthly Bulletins for May-June, 1932, January-February, 1933, and May-June, 1933.

DAIRY PUBLICATIONS OF THE EXPERIMENT STATION, WOOSTER, OHIO

BULLETINS

267, The value of soybean and alfalfa hay in milk production.
289, Raising dairy heifers, cost, feeding, and care.
327, Clover vs. alfalfa hay for milk production.
334, Dairy production in Ohio.
295, 308, 330, and 363, Mineral metabolism of the milch cow.
347, Utilization of calcium compounds in animal nutrition.
369, Field corn and silage corn for silage.
370, Losses and exchanges of material during the storage of corn as silage.
376, The effect of high and low protein content on the digestibility and metabolism of dairy rations.
389, Protein requirement of dairy cows.
424, Dairy and other livestock production costs in Medina County, Ohio.
455, Dicalcium phosphate as a mineral supplement for dairy cows.
469, The development of market milk areas in northeastern Ohio.
477, Studies on the nutritive value of milk, I. Deficiencies of exclusive milk diets.
498, A market analysis of farm sales of milk to dealers in four Ohio cities.
502, Preparation of feeds for dairy cows.
515, The chemical composition and nutritive properties of milk as affected by the level of protein feeding. Parts I and II.
518, Studies on the nutritive value of milk, II. Effect of pasteurization.
523, Sources of market milk and butterfat in Ohio.

CIRCULARS

122, Testing the dairy cow.
128, Feeding dairy cows.
134, The care of cream.
135, Building up the dairy herds of Ohio.
136, Care of the dairy herd.

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Sept. 1917, Raising dairy heifers, costs.
Oct. 1917, Economy of production by dairy cows.
Nov. 1917, Nutrients returned by dairy cows.
Dec. 1917, Stage of lactation affects milk yield.
Dec. 1917, Roughages for milk production.
Apr. 1918, A neglected source of valuable human food (Cottage cheese, food value, manufacture, and sale).
Oct. 1918, Manurial value of dairy feeds.
Dec. 1918, How to determine the cost of milk—I.
Dec. 1918, Centrifugal recovery of cheese from buttermilk.
Jan. 1919, How to determine the cost of milk—II.
July 1919, Ohio Experiment Station dairy herd.
Sept. 1919, Recovering cottage cheese curd from buttermilk.
Oct. 1919, Home-mixed or proprietary feeds for the dairy herd.
Dec. 1919, Usefulness of production records in dairy management.

Sept. 1921, Crop rotations for a dairy farm.
Apr. 1922, A case of twinning in dairy cattle.
Dec. 1922-May 1923, Raising and feeding dairy steers.
Dec. 1923, Abnormal fermentation in milk (ropy milk).

BIMONTHLY BULLETIN ARTICLES

March-April, 1925, Minerals in the dairy ration.
May-June, 1925, Selecting foundation dairy cows.
July-Aug., 1925, Alfalfa and clover hay for dairy heifers.
Jan.-Feb., 1926, A dairy cow, Grace Daw 2d, and her progeny.
May-June, 1926, Alfalfa and soybean hay for growing heifers.
July-Aug., 1926, Soybeans and soybean oilmeal for milk production.
Sept.-Oct., 1926, Soybean hay and soybean silage.
Nov.-Dec., 1926, Liberality and economy in feeding of dairy cows.
March-April, 1927, Butterfat tests of first and later lactations.
Jan.-Feb., 1928, Hay for dairy cattle.
March-April, 1928, Effect of high and low protein rations on milk for calves.
March-April, 1928, Succulent dairy feeds.
May-June, 1928, High protein grains supplement to pasture for dairy cows.
May-June, 1928, Gold medal cows in Station dairy herd.
July-Aug., 1928, The possibility of producing iodized milk.
Sept.-Oct., 1928, A study of certain processes for fermenting or enzymatizing feeds.
Nov.-Dec., 1928, The effect of the cow's ration on the food value of milk.
Nov.-Dec., 1928, The effect of the cow's ration on the vitamin-A and vitamin-B content of milk.
Jan.-Feb., 1929, Preparing grain mixtures of specified protein content.
Mar.-Apr., 1929, Powdered skimmilk as a feed for dairy calves.
Mar.-Apr., 1929, The effect of the cow's ration on the vitamin-D content of milk.
May-June, 1929, High protein grains. Are they needed as a supplement to pasture for dairy cows, II?
Nov.-Dec., 1929, How long should Holstein calves receive milk?
May-June, 1930, Dicalcium phosphate as a mineral supplement for dairy cows, I. Effect on health.
July-Aug., 1930, Dicalcium phosphate as a mineral supplement for dairy cows, II. Effect on milk production.
Nov.-Dec., 1930, How much protein in the grain mixture will return the dairyman most profit.
Jan.-Feb., 1931, Corn silage versus a mixture of wet beet pulp and molasses for milk production.
Jan.-Feb., 1931, Does the feeding of corn silage to dairy cows lead to acidosis?
May-June, 1931, A system of processing roughages for dairy cows.
Sept.-Oct., 1931, Cocoanut meal in the dairy ration.
Nov.-Dec., 1931, Wheat as a substitute for corn in the dairy ration.
Jan.-Feb., 1932, Raw versus pasteurized milk.
Mar.-Apr., 1932, Two years' feeding of Manamar to a herd of dairy cows.
May-June, 1932, Increasing the vitamin-D content of milk. I.
Sept.-Oct., 1932, The possibility of a home-grown dairy ration.
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Mar.-Apr., 1933, Pasturing Sudan grass at Wooster.
May-June, 1933, Vitamin-D milk.

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